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(54) **A method of synchronizing and channel estimation in a TDMA radio communication system.**

(57) The invention relates to a method of synchronizing a received signal frame in a TDMA radio system with a locally generated (TR) training sequence and of determining a channel estimate based on the comparison of the received signal frame and the locally generated training sequence. A first vector comprising M correlation values is calculated. In this vector the position m_w of the centre of energy is determined. A second vector comprising N consecutive correlation values distributed around the centre of energy m_w is chosen to form the channel estimate. The centre of energy in the second vector can be chosen as synchronizing position.

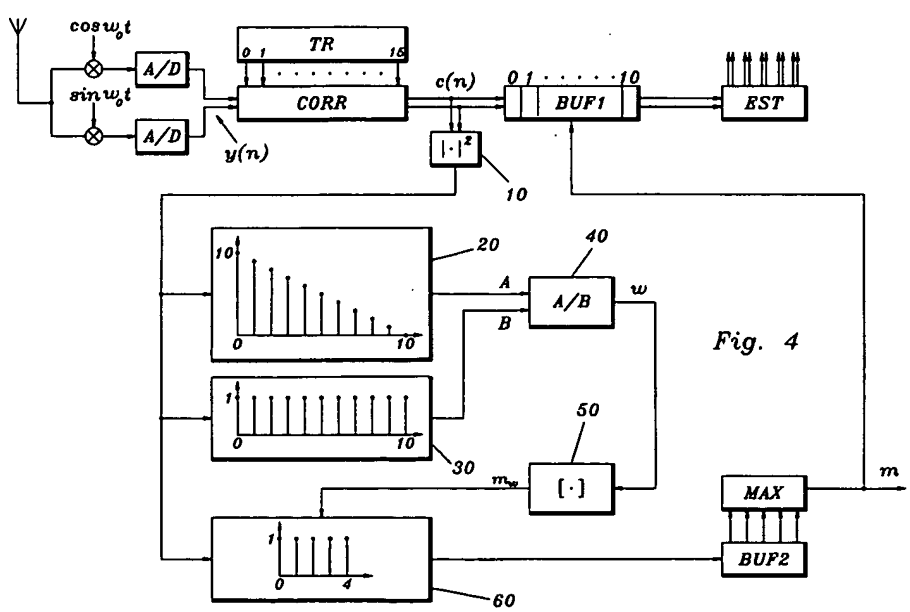


Fig. 4

TECHNICAL FIELD

The present invention relates to a method of synchronizing and channel estimation in a TDMA radio communication system.

BACKGROUND OF THE INVENTION

In TDMA radio communication systems (TDMA = Time Division Multiple Access) information is transmitted on a channel in the form of signal frames, that are transmitted by the transmitter during evenly distributed time intervals. In the spaces between these signal frames the transmitter is "silent". In order to synchronize the receiver to these signal frames each signal frame comprises a known synchronization word in predetermined positions within the signal frame. In for instance the European GSM system for mobile telephony this synchronization word is 26 bits long. When the receiver expects a new signal frame from the transmitter a training sequence, that is identical to the 16 central bits of the synchronization word, is generated by a training sequence generator in the receiver. The received signals are compared to the locally generated training sequence, and when the best possible correlation is obtained between this sequence and the received signals synchronization is considered to exist between the locally generated and the received signal.

In addition to the synchronization itself the training sequence is also used for channel estimation. Since the radio channel often is subjected to multiple path propagation the receiver comprises some sort of equalizer to eliminate this phenomenon. The equalizer requires a time limited estimate of the impulse response of the channel. This impulse response can be obtained from the correlation signal. For this purpose not only a synchronization position but an interval or a window defining the multiple path propagation and indicating where the equalizer is to operate is required.

A previously known method of finding the position of the window of the equalizer is to choose that interval of fixed length that contains most of the energy from the correlation. A drawback of this method is that disturbances in the received signal can give a correlation peak far away from the actual peak. For this reason the disturbance has a large instantaneous influence on the position of the window and creates a variance (uncertainty) in this position, which results in deteriorated receiver performance.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method of determining a more robust channel estimate in a TDMA radio communication system.

This object is achieved by a method with the characterizing features of claim 1.

Another object of the invention is a method of determining the synchronization position in a signal frame of a TDMA radio communication system.

This object is achieved by a method with the characterizing features of claim 10.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with further objects and advantages thereof, may best be understood by making reference to the following description taken together with the accompanying drawings, in which:

- FIGURE 1 shows a correlation-time diagram illustrating a previously known method to determine the synchronization position and channel estimate in a TDMA radio communication system;
- FIGURE 2 shows a corresponding correlation-time diagram in a case where the radio channel is subjected to disturbance;
- FIGURE 3 shows a correlation-time diagram illustrating the method of the invention in the disturbed case of Figure 2;
- FIGURE 4 shows a preferred embodiment of an apparatus for performing the method in accordance with the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows a correlation-time diagram, in which the sampling instances n run along the X-axis and the squared magnitude of the correlation between the locally generated training sequence and the received signal runs along the Y-axis.

The invention will be described below with reference to the European GSM-system. In this system a synchronization word comprises 26 bits. The 16 central bits in this word have good correlation properties when correlated with the entire synchronization word, that is a maximum correlation = 16 in the central position and a correlation of 0 in the remaining ten positions (C(k) = [0 0 0 0 0 16 0 0 0 0 0]). These 16 central bits are generated as a training sequence in a training sequence generator in the receiver. This training sequence is used for forming for instance 11 correlation values with the received signal frame. The squared magnitudes of these correlation values c(n) are shown in Figure 1. The final synchronization position is chosen by comparing mutually displaced windows, each containing 5 correlation values, with respect to energy contents. The central position of that window that contains most energy is outputted as the synchronization position. Additionally the 5 correlation values c(n) within this window are outputted as a channel estimate to the equalizer. In Figure 1 the different windows have been indicated with reference designations 2-8, where these numbers indicate the central positions of the windows in the correlation vector that is formed by the 11 correlation values. In the example shown in Figure 1 the previously known method will therefore choose synchronization position m = 3, since the correlation peak lies at position 3 and the energy also is concentrated around this position.

In practice the correlation peak is not as unambiguously defined as in Figure 1. Rather the received signal is disturbed by noise and by other transmitters, which results in disturbed channel estimates. Figure 2 shows an unfavourable case, in which a disturbance peak has been introduced into correlation position 8. If this peak is sufficiently high the result of the previously known method can be that the total energy for 5 correlation values happens to be larger around the disturbance than around the correlation peak. In this case the previously known method can therefore set m = 8 instead of the proper value 3. Furthermore, the channel equalizer will receive correlation values around the disturbance peak at m = 8, which means that the equalizer receives a very poor estimate, since the estimate is based on a disturbance peak.

Figure 3 illustrates a preferred embodiment of the method in accordance with the invention.

The method in accordance with the invention can be divided into several steps. In a first step the centre of energy w is calculated in accordance with the formula:

$$w = \frac{\sum_{k=0}^{M-1} k\,|c(k)|^2}{\sum_{k=0}^{M-1} |c(k)|^2}$$

where M is the number of correlation values. A suitable value for M has proven to be for instance the value 11. The obtained value is rounded to a preliminary window position m_w by rounding the obtained value w to the nearest integer.

In a second step the energy of the correlation values c(n) that are contained in two windows around this preliminary central window position are calculated in accordance with the formula:

$$E_n = \sum_{j=-K}^{K} |c(j+m_w+n)|^2 \qquad n = 0,1$$

where 2K + 1 = N, that is the number of correlation values in each window, for instance 5. In Figure 3 this method implies that w will lie near 3, the preliminary window centre position will be rounded to 3, and two windows centered around positions 3 and 4 are compared with respect to energy contents. The coefficients c(n) of that window that has the largest energy content is outputted to the equalizer as a channel estimate.

The final synchronization position m can be decided in several ways. One way is, as in the previously known method, to simply choose the centre position of the window. Another way is to determine the centre of energy in the chosen window in accordance with the formula:

$$x = \frac{\sum_{j=-K}^{K} j\,|c(j+m_w+n)|^2}{\sum_{j=-K}^{K} |c(j+m_w+n)|^2}$$

where $m_w + n$ designates the central position in a chosen window.

In the example described only two windows around the preliminary window centre position m_w are examined. However, it is possible to choose more windows than two. For instance 5 windows can be chosen around the preliminary window centre position m_w. The number of windows can for instance be chosen in dependence of the current time dispersion. For instance the number of windows can be chosen proportionally to the delay spread s defined in accordance with the formula:

$$s = \sqrt{\frac{\sum_{k=0}^{M-1} (k-w)^2\,|c(k)|^2}{\sum_{k=0}^{M-1} |c(k)|^2}}$$

Furthermore it is appreciated that the number of correlation values in each window is not limited to 5, but that other values are also possible.

An essential advantage of the present invention is that the determination of the centre of energy and the locking of the search window to values around this centre gives a more robust determination of both the synchronization position and the channel estimate. The reason for this is that a single disturbance peak in the correlation does not have such a strong influence on the calculation of the centre of energy.

A preferred embodiment of an apparatus for performing the method in accordance with the invention will now be described with reference to Figure 4.

The signal received by the receiver over an antenna is in a mixer converted to a base band signal and is in two A/D-converters divided into a complex input signal y(n) in a conventional way. This input signal is in a correlator CORR correlated with a training sequence from a training sequence generator TR local to said receiver. This training sequence generator outputs 16 values to correlator CORR. The correlation values c(n) of correlator CORR are stored in a buffer BUF1. In the example this buffer contains 11 memory positions for 11 complex correlation values c(n).

In a unit 10 the square of the magnitude of each correlation value c(n) is formed. These squared values are outputted to a summation unit 20, which calculates a weighted average of the 11 input signals, where the weighting coefficients in integer steps run from 10 down to 0. Summation unit 20 can for instance be realized as an FIR-filter. In a similar way the sum of the squared magnitudes of the correlation coefficients c(n) are formed in a summation unit 30. This unit can also be realized as a FIR-filter, in which the filter coefficients are all set equal to 1.

The output signal A from summation unit 20 is in a division unit 40 divided by the output signal B from summation unit 30 for forming the centre of energy w. In a rounding unit 50 w is rounded to the nearest integer m_w. This value locks the reference position for a summation unit 60, for instance a FIR-filter, that performs the energy calculation for for instance 5 windows distributed around position m_w and mutually displaced one sampling step, each window containing the squared magnitudes of each 5 correlation values c(n). These 5 sums, which represent the energy within each window, are stored in a buffer BUF2. In a unit MAX these 5 values are compared and the largest value is chosen, that is that window is chosen that had the largest energy content. As output signal the centre position m in this window can for instance be outputted. In this embodiment this output signal also defines the synchronization position. Alternatively the centre of energy within the window can be calculated as indicated above for the final determination of the synchronization position.

The window centre position m is also inputted to buffer BUF1, from which 5 correlation values c(n) centered around this position are chosen for transfer to a memory unit EST for storing the channel estimate. These 5 complex values are then transferred to the equalizer for channel equalization.

The present invention has been described with reference to the European GSM-system. However, it is appreciated that the same principles also can be used in for instance the American mobile radio communication system in accordance with the standard IS-54. In fact the invention can be used in any TDMA-system that is based on synchronization of a received signal with a locally generated training sequence.

It will be understood by those skilled in the art that various modifications and changes may be made to the present invention without departure from the spirit and scope thereof, which is defined by the appended claims.

Claims

1. A method in a TDMA radio communication system for choosing from a first vector comprising M correlation values between a synchronization sequence and M parts of a signal frame, which are partially overlapping and mutually displaced one sampling interval, a second vector of N correlation values for channel estimation, **characterized by**
   - calculating the centre of energy w of said first vector in accordance with the formula

$$w = \frac{\sum_{k=0}^{M-1} k\,|c(k)|^2}{\sum_{k=0}^{M-1} |c(k)|^2}$$

     where c(k) designates correlation value k in said first vector;
   - rounding the calculated value w to the nearest integer for forming a preliminary window centre position m_w in said first vector; and
   - choosing N consecutive correlation values distributed around said preliminary window centre position m_w for forming said second vector.

2. The method of claim 1, **characterized by**
   - choosing 2L+1 partially overlapping vectors which are mutually time displaced one sampling interval, each comprising N=2K+1 consecutive correlation values distributed around said preliminary window centre position m_w; and
   - choosing that of the 2L+1 chosen vectors that has the largest energy content E_n, that is that vector that maximizes the expression

$$E_n = \sum_{j=-K}^{K} |c(j+m_w+n)|^2 \qquad n = -L, \ldots, L$$

     as said second vector.

3. The method of claim 2, **characterized by** choosing L in dependence of the current time dispersion.

4. The method of claim 3, **characterized in** choosing L proportional to the delay spread s defined in accordance with

$$s = \sqrt{\frac{\sum_{k=0}^{M-1} (k-w)^2\,|c(k)|^2}{\sum_{k=0}^{M-1} |c(k)|^2}}$$

5. The method of claim 1, **characterized by**
   - choosing two partially overlapping vectors that are mutually time displaced one sampling interval, each comprising $N=2K+1$ consecutive correlation values surrounding said preliminary window centre position m_w; and
   - choosing that of the two chosen vectors that has the largest energy content E_n, that is that vector that maximizes the expression

$$E_n = \sum_{j=-K}^{K} |c(j+m_w+n)|^2 \qquad n = 0,1$$

as said second vector.

6. The method of any of claims 2-5, characterized by outputting the position of the centre position of said second vector in said first vector as final synchronization position m.

7. The method of any of claims 2-5, **characterized by**
   - calculating the centre of energy x within said chosen second vector in accordance with the formula

$$x = \frac{\sum_{j=-K}^{K} j\,|c(j+m_w+n)|^2}{\sum_{j=-K}^{K} |c(j+m_w+n)|^2}$$

where m_w+1 designates the centre position of said second vector in said first vector;
   - adding the value of x to the centre position m_w+1 of said second vector; and
   - outputting the position obtained in the previous step as final synchronization position m.

8. The method of any of the preceeding claims, **characterized by** said first vector comprising 11 correlation values, that is $M=11$.

9. The method of any of the preceeding claims, **characterized by** said second vector comprising 5 correlation values, that is $N=5$.

10. A method in a TDMA radio communication system for determining from a vector comprising M correlation values between a synchronization sequence and M parts of a signal frame, which parts are partially overlapping and mutually time displaced one sampling interval, the synchronization position m of said fram in said vector, **characterized by**
    - calculating the centre of energy w in accordance with the formula

$$w = \frac{\sum_{k=0}^{M-1} k\,|c(k)|^2}{\sum_{k=0}^{M-1} |c(k)|^2}$$

where c(k) designates correlation value k in said vector, said calculated centre of energy value w forming the sought synchronization position m.

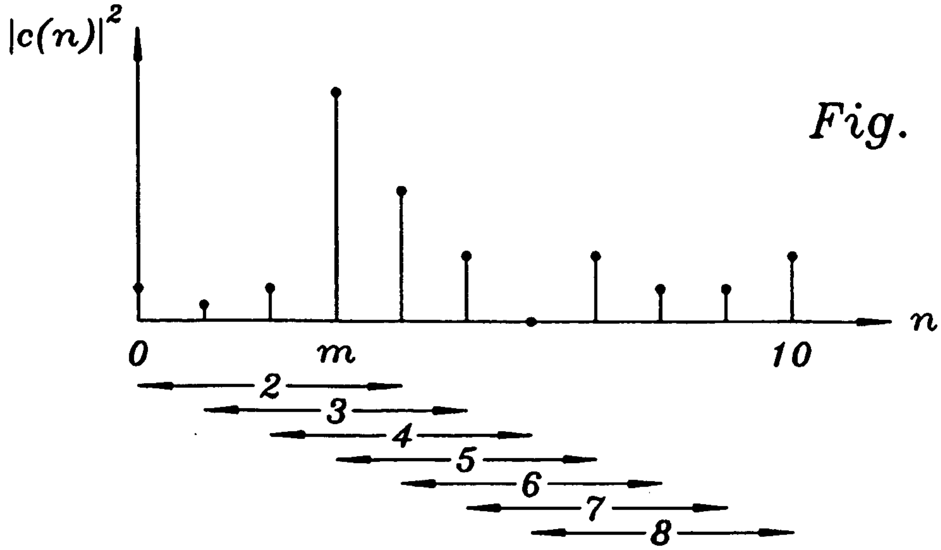


Fig. 1

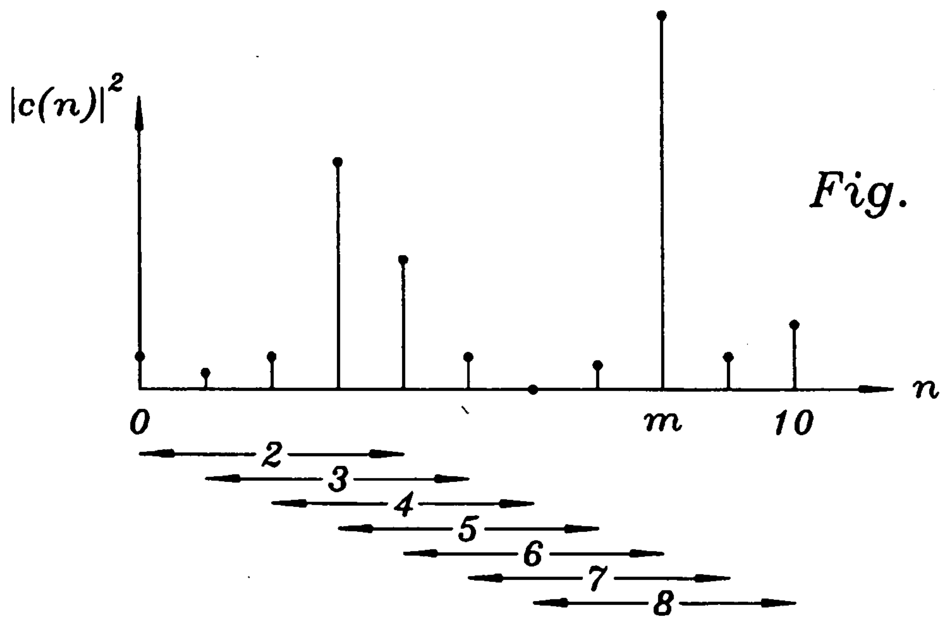


Fig. 2

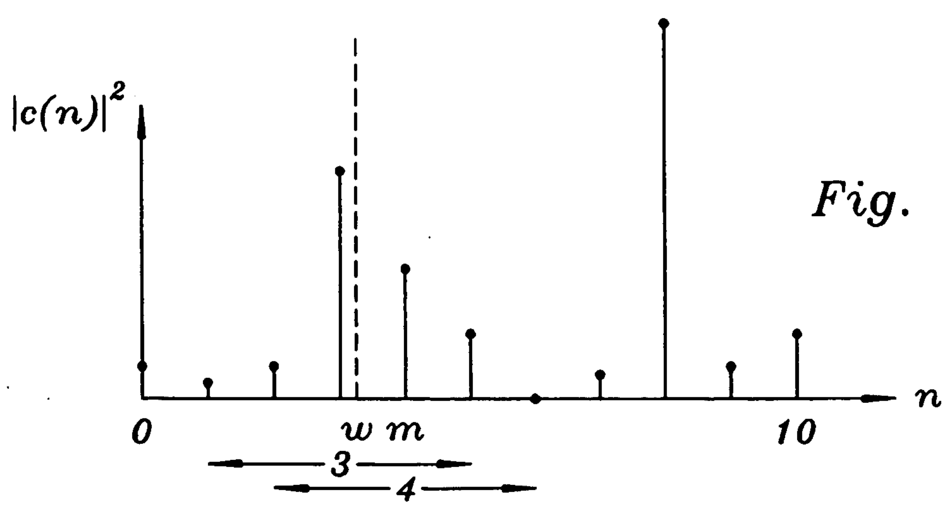
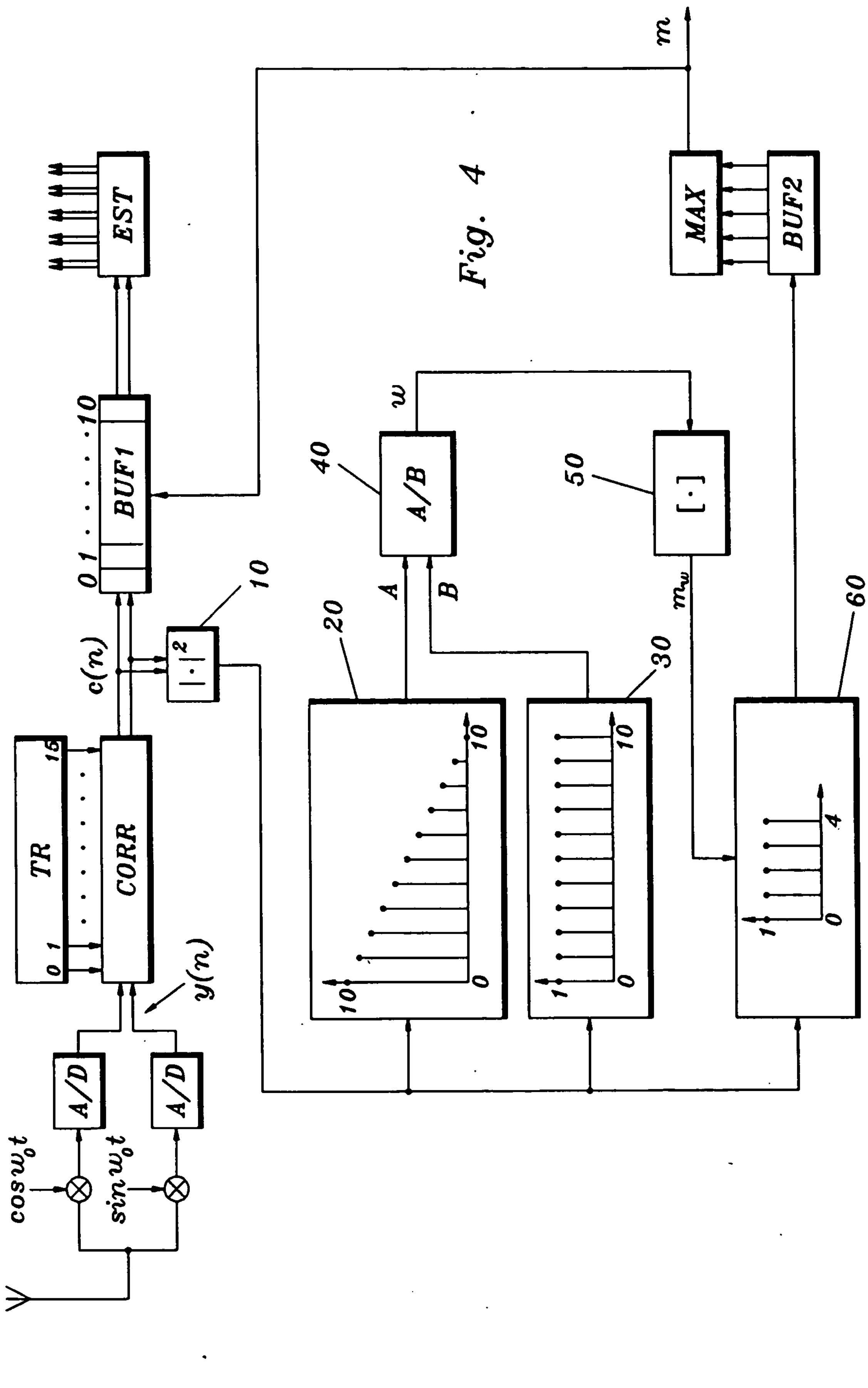


Fig. 3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y(n)
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$\sin w_0 t$
10
0
10
1
0
10
1
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4

Fig. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

92850290.5

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A- 4 873 683 (D.E. BORTH et al) *Column 3, line 49 - column 4, line 19* --	1-10	H04J 3/06 H04B 7/24
A	EP-A- 0 295 226 (TELEFONAKTIEBOLAGET L M ERICSSON) *Column 4, line 45 - column 5, line 10*	1-10	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H04B
H04L
H04Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
STOCKHOLM	06.04.1993	NYLANDER.M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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(54) **A method of synchronizing and channel estimation in a TDMA radio communication system**

Verfahren zur Synchronisierung und Kanalschätzung in einem TDMA-Radiokommunikationssystem

Méthode de synchronisation et d'estimation de canal dans un système de radiocommunication à accès multiple et à division de temps

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(56) References cited:
EP-A- 0 295 226 **US-A- 4 873 683**

EP 0 551 803 B1

Description

TECHNICAL FIELD

The present invention relates to a method of synchronizing and channel estimation in a TDMA radio communication system.

BACKGROUND OF THE INVENTION

In TDMA radio communication systems (TDMA = Time Division Multiple Access) information is transmitted on a channel in the form of signal frames, that are transmitted by the transmitter during evenly distributed time intervals. In the spaces between these signal frames the transmitter is "silent". In order to synchronize the receiver to these signal frames each signal frame comprises a known synchronization word in predetermined positions within the signal frame. In for instance the European GSM system for mobile telephony this synchronization word is 26 bits long. When the receiver expects a new signal frame from the transmitter a training sequence, that is identical to the 16 central bits of the synchronization word, is generated by a training sequence generator in the receiver. The received signals are compared to the locally generated training sequence, and when the best possible correlation is obtained between this sequence and the received signals, synchronization is considered to exist between the locally generated and the received signal.

In addition to the synchronization itself the training sequence is also used for channel estimation. Since the radio channel often is subjected to multiple path propagation the receiver comprises some sort of equalizer to eliminate this phenomenon. The equalizer requires a time limited estimate of the impulse response of the channel. This impulse response can be obtained from the correlation signal. For this purpose not only a synchronization position but an interval or a window defining the multiple path propagation and indicating where the equalizer is to operate is required.

A previously known method of finding the position of the window of the equalizer (cf. for example documents US-A-4873683 and EP-A-0295226) is to choose that interval of fixed length that contains most of the energy from the correlation. A drawback of this method is that disturbances in the received signal can give a correlation peak far away from the actual peak. For this reason the disturbance has a large instantaneous influence on the position of the window and creates a variance (uncertainty) in this position, which results in deteriorated receiver performance.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method of determining a more robust channel estimate in a TDMA radio communication system.

This object is achieved by a method with the characterizing features of claim 1.

Another object of the invention is a method of determining the synchronization position in a signal frame of a TDMA radio communication system.

This object is achieved by a method with the characterizing features of claim 10.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with further objects and advantages thereof, may best be understood by making reference to the following description taken together with the accompanying drawings, in which:

FIGURE 1 shows a correlation-time diagram illustrating a previously known method to determine the synchposition and channel estimate in a TDMA radio communication system;

FIGURE 2 shows a corresponding correlation-time diagram in a case where the radio channel is subjected to disturbance;

FIGURE 3 shows a correlation-time diagram illustrating the method of the invention in the disturbed case of Figure 2;

FIGURE 4 shows a preferred embodiment of an apparatus for performing the method in accordance with the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows a correlation-time diagram, in which the sampling instances n run along the X-axis and the squared magnitude of the correlation between the locally generated training sequence and the received signal runs along the

Y-axis.

The invention will be described below with reference to the European GSM-system. In this system a synchronization word comprises 26 bits. The 16 central bits in this word have good correlation properties when correlated with the entire synchronization word, that is a maximum correlation = 16 in the central position and a correlation of 0 in the remaining ten positions (C(k) = [0 0 0 0 0 16 0 0 0 0 0]). These 16 central bits are generated as a training sequence in a training sequence generator in the receiver. This training sequence is used for forming for instance 11 correlation values with the received signal frame. The squared magnitudes of these correlation values c(n) are shown in Figure 1. The final synchronization position is chosen by comparing mutually displaced windows, each containing 5 correlation values, with respect to energy contents. The central position of that window that contains most energy is outputted as the synchronization position. Additionally the 5 correlation values c(n) within this window are outputted as a channel estimate to the equalizer. In Figure 1 the different windows have been indicated with reference designations 2-8, where these numbers indicate the central positions of the windows in the correlation vector that is formed by the 11 correlation values. In the example shown in Figure 1 the previously known method will therefore choose synchronization position m=3, since the correlation peak lies at position 3 and the energy also is concentrated around this position.

In practice the correlation peak is not as unambiguously defined as in Figure 1. Rather the received signal is disturbed by noise and by other transmitters, which results in disturbed channel estimates. Figure 2 shows an unfavourable case, in which a disturbance peak has been introduced into correlation position 8. If this peak is sufficiently high the result of the previously known method can be that the total energy for 5 correlation values happens to be larger around the disturbance than around the correlation peak. In this case the previously known method can therefore set m=8 instead of the proper value 3. Furthermore, the channel equalizer will receive correlation values around the disturbance peak at m=8, which means that the equalizer receives a very poor estimate, since the estimate is based on a disturbance peak.

Figure 3 illustrates a preferred embodiment of the method in accordance with the invention.

The method in accordance with the invention can be divided into several steps. In a first step the centre of energy w is calculated in accordance with the formula:

$$w = \frac{\sum_{k=0}^{M-1} k|c(k)|^2}{\sum_{k=0}^{M-1} |c(k)|^2}$$

where M is the number of correlation values. A suitable value for M has proven to be for instance the value 11. The obtained value is rounded to a preliminary window position m_w by rounding the obtained value w to the nearest integer.

In a second step the energy of the correlation values c(n) that are contained in two windows around this preliminary central window position are calculated in accordance with the formula:

$$E_n = \sum_{j=-K}^{K} |c(j+m_w+n)|^2 \qquad n = 0,1$$

where 2K+1=N that is the number of correlation values in each window, for instance 5. In Figure 3 this method implies that w will lie near 3, the preliminary window centre position will be rounded to 3, and two windows centered around positions 3 and 4 are compared with respect to energy contents. The coefficients c(n) of that window that has the largest energy content is outputted to the equalizer as a channel estimate.

The final synchronization position m can be decided in several ways. One way is, as in the previously known method, to simply choose the centre position of the window. Another way is to determine the centre of energy in the chosen window in accordance with the formula:

$$x = \frac{\sum_{j=-K}^{K} j\,|c(j+m_w+n)|^2}{\sum_{j=-K}^{K} |c(j+m_w+n)|^2}$$

where m_w+n designates the central position in a chosen window.

In the example described only two windows around the preliminary window centre position m_w are examined. However, it is possible to choose more windows than two. For instance 5 windows can be chosen around the preliminary window centre position m_w. The number of windows can for instance be chosen in dependence of the current time dispersion. For instance the number of windows can be chosen proportionally to the delay spread s defined in accordance with the formula:

$$s = \sqrt{\frac{\sum_{k=0}^{M-1} (k-w)^2\,|c(k)|^2}{\sum_{k=0}^{M-1} |c(k)|^2}}$$

Furthermore it is appreciated that the number of correlation values in each window is not limited to 5, but that other values are also possible.

An essential advantage of the present invention is that the determination of the centre of energy and the locking of the search window to values around this centre gives a more robust determination of both the synchronization position and the channel estimate. The reason for this is that a single disturbance peak in the correlation does not have such a strong influence on the calculation of the centre of energy.

A preferred embodiment of an apparatus for performing the method in accordance with the invention will now be described with reference to Figure 4.

The signal received by the receiver over an antenna is in a mixer converted to a base band signal and is in two A/D-converters divided into a complex input signal y(n) in a conventional way. This input signal is in a correlator CORR correlated with a training sequence from a training sequence generator TR local to said receiver. This training sequence generator outputs 16 values to correlator CORR. The correlation values c(n) of correlator CORR are stored in a buffer BUF1. In the example this buffer contains 11 memory positions for 11 complex correlation values c(n).

In a unit 10 the square of the magnitude of each correlation value c(n) is formed. These squared values are outputted to a summation unit 20, which calculates a weighted average of the 11 input signals, where the weighting coefficients in integer steps run from 10 down to 0. Summation unit 20 can for instance be realized as an FIR-filter. In a similar way the sum of the squared magnitudes of the correlation coefficients c(n) are formed in a summation unit 30. This unit can also be realized as a FIR-filter, in which the filter coefficients are all set equal to 1.

The output signal A from summation unit 20 is in a division unit 40 divided by the output signal B from summation unit 30 for forming the centre of energy w. In a rounding unit 50 w is rounded to the nearest integer m_w. This value locks the reference position for a summation unit 60, for instance a FIR-filter, that performs the energy calculation for for instance 5 windows distributed around position m_w and mutually displaced one sampling step, each window containing the squared magnitudes of each 5 correlation values c(n). These 5 sums, which represent the energy within each window, are stored in a buffer BUF2. In a unit MAX these 5 values are compared and the largest value is chosen, that is that window is chosen that had the largest energy content. As output signal the centre position m in this window can for instance be outputted. In this embodiment this output signal also defines the synchronization position. Alternatively the centre of energy within the window can be calculated as indicated above for the final determination of the synchronization position.

The window centre position m is also inputted to buffer BUF1, from which 5 correlation values c(n) centered around this position are chosen for transfer to a memory unit EST for storing the channel estimate. These 5 complex values are then transferred to the equalizer for channel equalization.

The present invention has been described with reference to the European GSM-system. However, it is appreciated that the same principles also can be used in for instance the American mobile radio communication system in accordance with the standard IS-54. In fact the invention can be used in any TDMA-system that is based on synchronization of a received signal with a locally generated training sequence.

It will be understood by those skilled in the art that various modifications and changes may be made to the present invention without departure from the scope thereof, which is defined by the appended claims.

Claims

1. A method in a TDMA radio communication system for choosing from a first vector comprising M correlation values between a synchronization sequence and M parts of a signal frame, which are partially overlapping and mutually displaced one sampling interval, a second vector of N correlation values for channel estimation, **characterized by**

   - calculating the centre of energy w of said first vector in accordance with the formula

   $$w = \frac{\sum_{k=0}^{M-1} k\,|c(k)|^2}{\sum_{k=0}^{M-1} |c(k)|^2}$$

   where c(k) designates correlation value k in said first vector;

   - rounding the calculated value w to the nearest integer for forming a preliminary window centre position m_w in said first vector; and
   - choosing N consecutive correlation values distributed around said preliminary window centre position m_w for forming said second vector.

2. The method of claim 1, **characterized by**

   - choosing 2L+1 partially overlapping vectors which are mutually time displaced one sampling interval, each comprising N=2K+1 consecutive correlation values distributed around said preliminary window centre position m_w; and
   - choosing that of the 2L+1 chosen vectors that has the largest energy content E_n, that is that vector that maximizes the expression

   $$E_n = \sum_{j=-K}^{K} |c(j+m_w+n)|^2 \qquad n = -L, \ldots, L$$

   as said second vector.

3. The method of claim 2, **characterized by** choosing L in dependence of the current time dispersion.

4. The method of claim 3, **characterized in** choosing L proportional to the delay spread s defined in accordance with

$$s = \sqrt{\frac{\sum_{k=0}^{M-1} (k-w)^2\,|c(k)|^2}{\sum_{k=0}^{M-1} |c(k)|^2}}$$

5. The method of claim 1, **characterized by**

- choosing two partially overlapping vectors that are mutually time displaced one sampling interval, each comprising N=2K+1 consecutive correlation values surrounding said preliminary window centre position m_w; and
- choosing that of the two chosen vectors that has the largest energy content E_n, that is that vector that maximizes the expression

$$E_n = \sum_{j=-K}^{K} |c(j+m_w+n)|^2 \qquad n = 0,1$$

as said second vector.

6. The method of any of claims 2-5, characterized by outputting the position of the centre position of said second vector in said first vector as final synchronization position m.

7. The method of any of claims 2-5, **characterized by**

- calculating the centre of energy x within said chosen second vector in accordance with the formula

$$x = \frac{\sum_{j=-K}^{K} j\,|c(j+m_w+n)|^2}{\sum_{j=-K}^{K} |c(j+m_w+n)|^2}$$

where m_w+1 designates the centre position of said second vector in said first vector;

- adding the value of x to the centre position m_w+1 of said second vector; and
- outputting the position obtained in the previous step as final synchronization position m.

8. The method of any of the preceeding claims, **characterized by** said first vector comprising 11 correlation values, that is M=11.

9. The method of any of the preceeding claims, **characterized by** said second vector comprising 5 correlation values, that is N=5.

10. A method in a TDMA radio communication system for determining from a vector comprising M correlation values between a synchronization sequence and M parts of a signal frame, which parts are partially overlapping and mutually time displaced one sampling interval, the synchronization position m of said fram in said vector, **characterized by**

- calculating the centre of energy w in accordance with the formula

$$w = \frac{\sum_{k=0}^{M-1} k\,|c(k)|^2}{\sum_{k=0}^{M-1} |c(k)|^2}$$

where c(k) designates correlation value k in said vector, said calculated centre of energy value w forming the

sought synchronization position m.

Patentansprüche

1. Verfahren in einem TDMA-Funkkommunikations-System, um aus einem ersten Vektor umfassend (M) Korrelationswerte zwischen einer Synchronisationssequenz und M Teilen eines Signalrahmens, die teilweise überlappen und zueinander um ein Abtastintervall versetzt sind, einen zweiten Vektor von N Korrelationswerten für eine Kanalschätzung auszuwählen, **gekennzeichnet durch:**

   - Berechnen des Zentrums der Energie w des ersten Vektors gemäß der Gleichung

   $$w = \frac{\sum_{k=0}^{M-1} k|c(k)|^2}{\sum_{k=0}^{M-1} |c(k)|^2}$$

   wobei c(k) einen Korrelationswert k in dem ersten Vektor bezeichnet;

   - Runden des berechneten Werts w zu der nächsten ganzen zahl zum Bilden einer vorläufigen Fensterzentralposition m_w in dem ersten Vektor; und

   - Wählen von N aufeinanderfolgenden Korrelationswerten, die um die vorläufige Fensterzentralposition m_w verteilt sind, zum Bilden des zweiten Vektors.

2. Verfahren nach Anspruch 1, **gekennzeichnet durch:**

   - Wählen von 2L+1 teilweise überlappenden Vektoren, die zueinander zeitlich um ein Abtastintervall versetzt sind, wobei jeder N = 2K + 1 aufeinander folgende Korrelationswerte, die um die vorläufige Fensterzentralposition m_w verteilt sind, umfaßt;

   - Wählen desjenigen der 2L+1 gewählten Vektoren, welcher den größten Energieinhalt E_n aufweist, das heißt, desjenigen Vektors, der die Beziehung

   $$E_n = \sum_{j=-K}^{K} |c(j + m_w + n)|^2 \qquad n = -L, \ldots, L$$

   maximiert, als den zweiten Vektor.

3. Verfahren nach Anspruch 2, **dadurch gekennzeichnet,** daß L in Abhängigkeit von der gegenwärtigen Zeitverteilung gewählt wird.

4. Verfahren nach Anspruch 3, **dadurch gekennzeichnet,** daß L proportional zu der Verzögerungsstreuung s gewählt wird, die gemäß

$$s = \sqrt{\frac{\sum_{k=0}^{M-1}(k-w)^2\left|c(k)\right|^2}{\sum_{k=0}^{m-1}\left|c(k)\right|^2}}$$

definiert ist.

5. Verfahren nach Anspruch 1, **gekennzeichnet durch die folgenden Schritte:**

- Wählen von zwei teilweise überlappenden Vektoren, die zueinander um ein Abtastintervall zeitlich versetzt sind, wobei jeder $N = 2K + 1$ aufeinanderfolgende Korrelationswerte, die die vorläufige Fensterzentralposition m_w umgeben, umfaßt;
- Wählen desjenigen der zwei Vektoren, der den größten Energieinhalt E_n aufweist, das heißt, desjenigen Vektors, der den Ausdruck

$$E_n = \sum_{j=-K}^{K}\left|c(j+m_w+n)\right|^2 \qquad n = 0,1$$

maximiert, als den zweiten Vektor.

6. Verfahren nach einem der Ansprüche 2 - 5, **gekennzeichnet durch den folgenden Schritt:** Ausgeben der Position der Zentralposition des zweiten Vektors in dem ersten Vektor als eine abschließende Synchronisationsposition m.

7. Verfahren nach einem der Ansprüche 2 - 5, **gekennzeichnet durch die folgenden Schritt:**

- Berechnen des Zentrums der Energie x innerhalb des gewählten zweiten Vektors gemäß der Formel

$$x = \frac{\sum_{j=-K}^{K} j\left|c(j+m_w+n)\right|^2}{\sum_{j=-K}^{K}\left|c(j+m_w+n)\right|^2}$$

wobei $m_w + 1$ die Zentralposition des zweiten Vektors in dem ersten Vektor bezeichnet;

- Addieren des Wertes von x zu der Zentralposition $m_w + 1$ des zweiten Vektors; und
- Ausgeben der Position, die in dem letzten Schritt erhalten wird, als eine abschließende Synchronisationsposition m.

8. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, daß** der erste Vektor 11 Korrelationswerte umfaßt, das heißt M = 11 ist.

9. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, daß** der zweite Vektor 5 Korrelationswerte umfaßt, das heißt N = 5 ist.

10. Verfahren in einem TDMA-Funkkommunikations-System, um aus einem Vektor umfassend M Korrelationswerte

zwischen einer Synchronisationssequenz und M Teilen eines Signalrahmens, wobei die Teile teilweise überlappen und zueinander zeitlich um ein Abtastintervall versetzt sind, die Synchronisationsposition m des Rahmens in dem Vektor zu bestimmen, **gekennzeichnet durch die folgenden Schritte:**

- Berechnen des Zentrums der Energie w gemäß der folgenden Formel

$$w = \frac{\sum_{k=0}^{M-1} k\left|c(k)\right|^2}{\sum_{k=0}^{M-1}\left|c(k)\right|^2}$$

  wobei c(k) einen Korrelationswert k in dem Vektor bezeichnet und wobei das berechnete Zentrum des Energiewerts w die gewünschte Synchronisationsposition m bildet.

Revendications

1. Procédé dans un système de radiocommunication AMRT pour choisir dans un premier vecteur comprenant M valeurs de corrélation entre une séquence de synchronisation et M parties d'une trame de signal, qui sont en chevauchement partiel et sont mutuellement déplacées d'un intervalle d'échantillonnage, un second vecteur de N valeurs de corrélation pour l'estimation de canal, caractérisé en ce que

   - on calcule le centre d'énergie w du premier vecteur, conformément à la formule :

   $$w = \frac{\sum_{k=0}^{M-1} k\left|c(k)\right|^2}{\sum_{k=0}^{M-1}\left|c(k)\right|^2}$$

     dans laquelle c(k) désigne une valeur de corrélation k dans le premier vecteur;
   - on arrondit à l'entier le plus proche la valeur w calculée, pour former une position centrale de fenêtre préliminaire m_w dans le premier vecteur; et
   - on choisit N valeurs de corrélation consécutives réparties autour de la position centrale de fenêtre préliminaire m_w, pour former le second vecteur.

2. Procédé selon la revendication 1, caractérisé en ce que

   - on choisit 2L+1 vecteurs en chevauchement partiel qui sont mutuellement déplacés dans le temps d'un intervalle d'échantillonnage, chacun d'eux comprenant N=2K+1 valeurs de corrélation consécutives réparties autour de la position centrale de fenêtre préliminaire m_w; et
   - on choisit pour le second vecteur celui des 2L+1 vecteurs choisis qui a le contenu en énergie E_n le plus élevé, c'est-à-dire le vecteur qui maximise l'expression

   $$E_n = \sum_{j=-K}^{K} \left|c(j+m_w+n)\right|^2 \qquad n = -L, \ldots, L$$

3. Procédé selon la revendication 2, caractérisé en ce qu'on choisit L sous la dépendance de la dispersion temporelle courante.

4. Procédé selon la revendication 3, caractérisé en ce qu'on choisit L proportionnel à l'étalement de retard s, défini conformément à :

$$s = \sqrt{\frac{\sum_{k=0}^{M-1} (k - w)^2 |c(k)|^2}{\sum_{k=0}^{M-1} |c(k)|^2}}$$

5. Procédé selon la revendication 1, caractérisé en ce que

- on choisit deux vecteurs en chevauchement partiel qui sont mutuellement déplacés dans le temps d'un intervalle d'échantillonnage, chacun d'eux comprenant N=2K+1 valeurs de corrélation consécutives qui entourent la position centrale de fenêtre préliminaire m_w; et
- on choisit pour le second vecteur celui des deux vecteurs choisis qui a le contenu en énergie E_n le plus élevé, c'est-à-dire le vecteur qui maximise l'expression :

$$E_n = \sum_{j=-K}^{K} |c(j+m_w+n)|^2 \qquad n = 0,\ 1$$

6. Procédé selon l'une quelconque des revendications 2 à 5, caractérisé en ce qu'on fournit en sortie, pour la position de synchronisation finale m, la position qui correspond à la position centrale du second vecteur dans le premier vecteur.

7. Procédé selon l'une quelconque des revendications 2 à 5, caractérisé en ce que

- on calcule le centre d'énergie x dans le second vecteur choisi, conformément à la formule :

$$x = \frac{\sum_{j=-K}^{K} j|c(j + m_w + n)|^2}{\sum_{j=-K}^{K} |c(j + m_w + n)|^2}$$

dans laquelle m_w+1 désigne la position centrale du second vecteur dans le premier vecteur;
- on additionne la valeur de x à la position centrale m_w+1 du second vecteur; et
- on fournit en sortie pour la position de synchronisation finale m la position qui est obtenue à l'étape précédente.

8. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que le premier vecteur comprend 11 valeurs de corrélation, c'est-à-dire M=11.

9. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que le second vecteur comprend 5 valeurs de corrélation, c'est-à-dire N=5.

10. Procédé dans un système de radiocommunication AMRT pour déterminer à partir d'un vecteur comprenant M valeurs de corrélation entre une séquence de synchronisation et M parties d'une trame de signal, ces parties étant en chevauchement partiel et étant mutuellement déplacées dans le temps d'un intervalle d'échantillonnage, la position de synchronisation m de ladite trame dans le vecteur, caractérisé en ce que

- on calcule le centre d'énergie w conformément à la formule :

$$w = \frac{\sum_{k=0}^{M-1} k|c(k)|^2}{\sum_{k=0}^{M-1} |c(k)|^2}$$

dans laquelle c(k) désigne une valeur de corrélation k dans le vecteur, cette valeur de centre d'énergie w qui est calculée formant la position de synchronisation m recherchée.

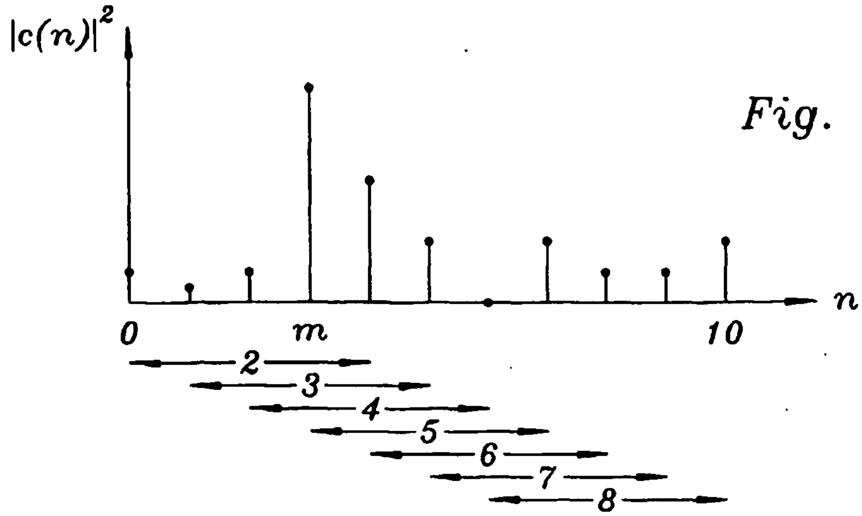

Fig. 1

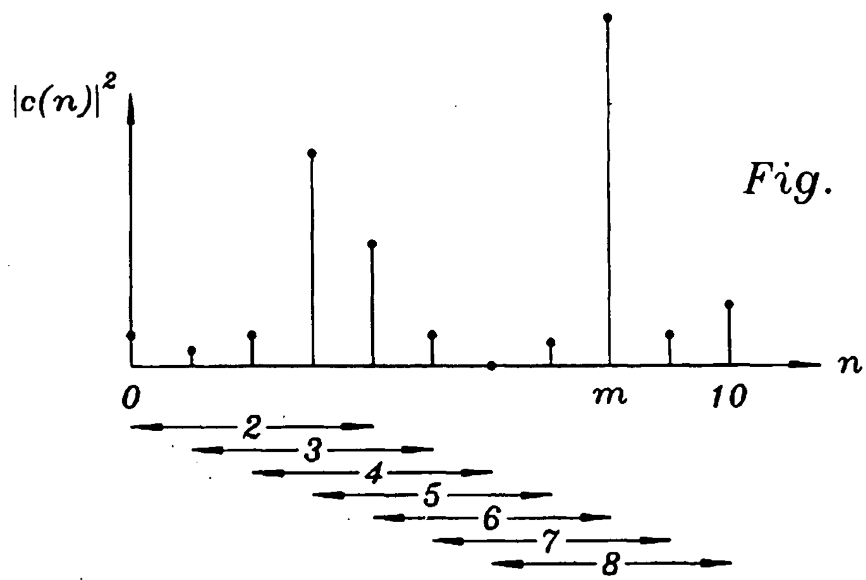

Fig. 2

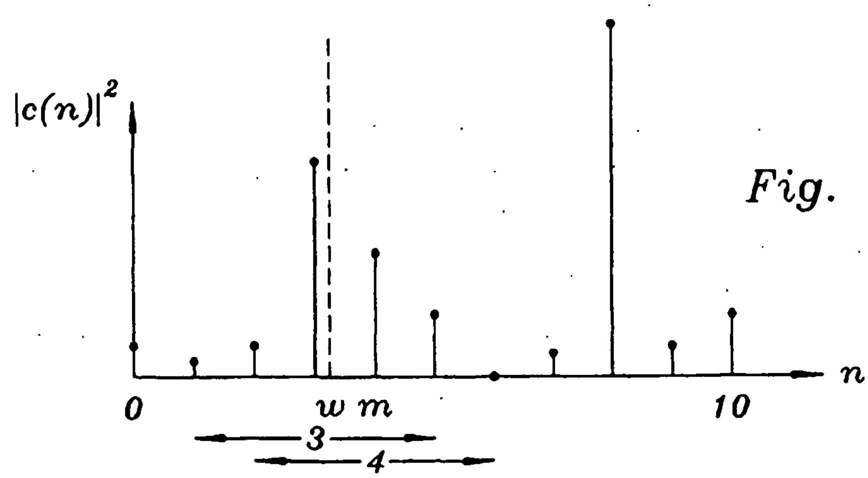

Fig. 3

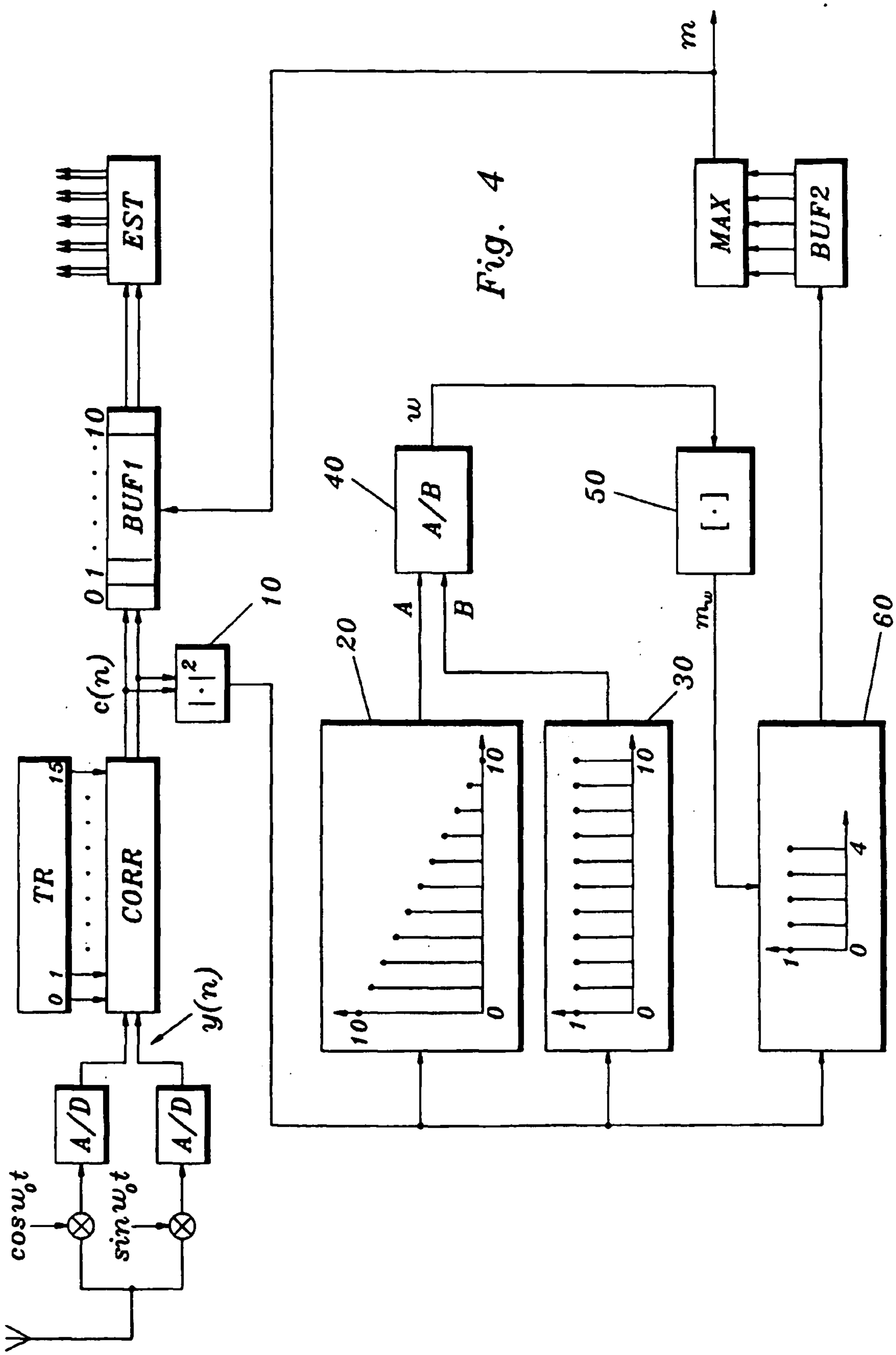
TR
CORR
BUF1
EST
A/D
A/D
$\cos w_0 t$
$\sin w_0 t$
$y(n)$
$c(n)$
$|\cdot|^2$
10
20
30
40
50
60
A/B
A
B
w
$[\cdot]$
m_w
MAX
BUF2
m

Fig. 4